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icist, and the electric furnace of the chemist are of almost equal importance with the telescope.

Professor Hale, in this most interesting volume, describes the new type of observatory and explains the work of a modern astronomer and the problems which confront him. From his great experience in designing and equipping two great modern institutions of astronomical research—the Yerkes and the Mount Wilson observatories—Professor Hale has drawn freely for concrete illustrations of the difficulties which confront the student of stellar evolution. He shows how the feeble rays of light from a scarcely visible star are gathered together by the giant lens or mirror of the telescope and brought into a physical laboratory, where they are analyzed by the spectroscope, and forced to reveal the secret of the star's evolution.

The book is essentially a popular treatise; it was planned as a handbook to the Yerkes Observatory. It is non-technical, readable and gives a clear explanation of the purposes and observational methods employed by the author in his notable researches upon the sun and the chemistry of the stars. The book is discursive, however: the problems are treated individually, without showing clearly their interrelation and their bearing upon the general problem of stellar evolution. But the work was not intended as a scientific presentation of the subject; it was planned for the general reader, not for the investigator. The illustrations, from photographs taken principally at the Yerkes and Mt. Wilson observatories, are very beautiful, but are, if anything, rather too numerous.

CHARLES LANE POOR

*ACTION OF THE RADIUM EMANATION ON
SOLUTIONS OF COPPER SALTS¹*

A year ago Messrs. Ramsay and Cameron announced in several journals that they had observed the formation of the alkali metals and of lithium in solutions of copper salts which had been subjected to the action of the

¹ Translated from the paper by Mme. Curie and Mlle. Gleditsch, *Comptes rendus*, 147, 345 (1908).

radium emanation. They concluded that the metal copper was *degraded*, in the presence of the emanation, into elements of the same series having lower atomic weights: potassium, sodium, lithium.¹

These important results attracted a great deal of attention and it seemed desirable to repeat the experiment in laboratories possessing a sufficient quantity of radium. The experiment to be repeated was as follows. A solution of a copper salt (sulphate or nitrate) was placed in a small glass flask into which was introduced a large amount of the emanation and this was allowed to decay spontaneously. The copper was then removed, the resulting solution was evaporated to dryness, and the residue examined. The same processes were performed with a solution of the same copper salt which had not been subjected to the action of the emanation. The experiments were repeated several times. The residue consisted chiefly of sodium salt (with a small amount of potassium and calcium). In the four experiments described, in which the emanation acted, lithium was detected by means of the spectroscope. In the blank experiments there was much less residue and the presence of lithium could not be detected. Messrs. Ramsay and Cameron made one experiment to determine the quantity of lithium observed and they estimate the presence of about 0.00017 milligram in the residue which weighed 1.67 milligrams, the amount of copper taken being 0.27 g. (0.815 g. copper nitrate). In the corresponding blank experiment the residue was only 0.79 milligrams.²

We have tried to reproduce the results under conditions as free from error as possible. The experiment is a delicate one and there are several sources of error, chief among them being the use of a glass vessel as Mr. Ramsay himself remarks.

¹ *Nature*, July, 1907; *Jour. Chem. Soc.*, September, 1907; *Comptes rendus*, 1908; *Archives de Genève*, April, 1908; etc.

² This quantity of metallic lithium does not check with the value indicated by the mixture of sodium and lithium salts which was taken as a comparison. There must be some error of calculation which we have not been able to locate.

Our preliminary experiments showed that it was very difficult to obtain chemical reagents which contained no lithium. We found it in the distilled water and in nearly all the reagents. If there were none in any reagent, it was only necessary to leave the reagent for a little while in a glass vessel; after some time, traces of lithium could be detected. The following experiment was made: When water has been distilled from a platinum retort and has been kept in a platinum flask, it leaves no visible residue when 250 c.c. are evaporated in a platinum dish; and the last drop, when thus concentrated, does not show the spectrum of lithium. But if water, prepared in the same way, is kept for twenty-four hours in a glass vessel, we find, on evaporation, a small residue consisting chiefly of a sodium salt but containing also a trace of lithium.

It seemed to us essential to replace glass by some other material. We have established that it is just as dangerous to use quartz, the material actually employed by Mr. Ramsay. The commercial quartz vessels contain lithium. Hydrofluoric acid containing no lithium was allowed to act on the fragments of an opaque quartz crucible and on a piece of a transparent quartz tube. In the residue there could be detected a notable quantity of lithium, and there was a good deal more of it in the transparent quartz than in the opaque quartz. We then decided to use platinum vessels.

The apparatus which we used consisted of a cylindrical platinum vessel, 7.5 cm. in length and 1.5 cm. outside diameter, placed horizontally. At one end of the vessel was a small vertical platinum tube through which we could introduce the solution. The small tube had a platinum cover which protected the solution but which did not make a tight joint. A glass tube, with a side-arm and a stop-cock, was fastened on the outside of the platinum tube. The solution was introduced into the apparatus by means of a platinum siphon and never came in contact for a moment with the glass of the apparatus.

The water and the acids necessary for the experiment were redistilled in platinum retorts and were kept in platinum bottles. We

found that all these reagents originally contained lithium, especially the sulphuric acid. After purification lithium could not be detected in the residues obtained by evaporating 80 c.c. of nitric acid, 25 c.c. of sulphuric acid, 25 c.c. of hydrofluoric acid and 250 c.c. of water.

As Mr. Ramsay himself points out, the so-called chemically pure salts of copper contain notable amounts of lithium. We have tried different methods of purification: repeated precipitation by hydrogen sulphide; electrolytic precipitation of copper; fractional crystallization. We have finally made use of copper sulphate which had been re-crystallized a number of times in a platinum dish, each solution being made up with pure water. At first this treatment is very effective; but it is very difficult, if not impossible, to remove the last traces of lithium. When we stopped further purification we could just manage to show the presence of lithium in the residue resulting from treating 50 g. of copper salt; but we could not detect its presence at all in the residue resulting from the treatment of 2 g. of salt.

The emanation was furnished by a solution containing 0.19 g. of radium (0.25 g. RaCl_2). It was first condensed in a condenser immersed in liquid air and then drawn over into the apparatus. In order to know accurately the amount of emanation introduced, we compared the penetrating radiation of the apparatus with that of a flask containing a known amount of radium. To do this we used a specially-prepared condenser having very large plates.

Two exactly comparable experiments were made. We introduced into the apparatus about 7 c.c. of a pure copper sulphate solution; the liquid had a large free surface relatively to its volume. The apparatus was sealed with a blow-pipe. The emanation was introduced in several lots; to ensure its dissolving, the solution was shaken by tipping the apparatus in its bath of melting ice. This operation was repeated a number of times. The amounts of metallic copper taken were 0.269 g. and 0.14 g. The total amount of emanation introduced was equivalent in both cases to the saturated

emanation from 0.37 g. of radium. The quantity of emanation which was effectively destroyed in the apparatus was a little less and was equivalent to the saturated emanation from 0.27 g. of radium. When the experiment was considered finished, the solution was transferred from the apparatus into a platinum crucible and a few drops of nitric acid added. Into this same crucible we dipped a piece of platinum foil on which we deposited the copper. When the solution was freed from copper, it was evaporated to dryness in the crucible and the latter was heated just enough to drive off the sulphuric acid. The residue was dissolved in a few drops of water and treated with hydrogen sulphide to remove the last traces of copper still remaining. The liquid was filtered through a platinum filter into a platinum watch-glass of known weight and was evaporated to dryness at a very moderate temperature. The minute residue was weighed.

The same treatment was applied to 7 c.c. of a copper sulphate solution which had not been subjected to the action of radium. The final residues were examined spectroscopically. Their weights were 0.0004 g. and 0.0005 g. in the real experiments, 0.0003 g. and 0.0002 g. in the blanks. It is to be noted that the amount of copper taken is very close to that used by Mr. Ramsay. The amount of emanation consumed is also approximately the same (1.85 mm.³ in Mr. Ramsay's phraseology). In spite of this, the residue finally obtained is much less.

The spectroscopic examination showed that the residue consisted chiefly of sodium with a little potassium; the presence of lithium could not be established. An experiment with a mixture of sodium and lithium sulphates showed that we could detect, though only with difficulty, the presence of one part of lithium sulphate in ten thousand parts of sodium sulphate. With the same ray it was easy to detect one part of lithium sulphate in three thousand parts of sodium sulphate. Consequently the amount of the metal lithium which could be present was less than 0.6×10^{-5} milligrams.

With the same amounts of copper and of

emanation, Messrs. Ramsay and Cameron found 1.7×10^{-4} milligrams of lithium. If there is an error in calculation and this number refers to lithium chloride, there would still be 3×10^{-5} milligrams of metallic lithium.

The residue which we obtained was in each case much less than that obtained by Messrs. Ramsay and Cameron and this difference is probably due to our not using glass vessels. The difference in the weights of the residues obtained by us in the real experiments and the blanks is very small (0.1 to 0.3 milligram). The difference is probably due to the introduction of traces of foreign substances into the apparatus along with the emanation. In the most reliable experiment of Messrs. Ramsay and Cameron, the same difference is 0.88 milligram and we believe that this is due to the solution attacking the glass more vigorously in presence of the emanation.

The following check experiment was made. Into a copper sulphate solution containing 0.27 g. of copper we introduced an amount of lithium sulphate corresponding to 1.7×10^{-4} milligrams of LiCl; this solution was then treated in the same way as in the other blank experiments. In the residue finally obtained it was very easy to see the red ray of lithium. This shows that the lithium was not eliminated by the treatment adopted.

To sum up, we must say that we have not succeeded in confirming the experiments of Messrs. Ramsay and Cameron. It is evidently impossible for us to say that no trace of sodium or lithium is formed during the experiment. We believe, however, that the formation of these elements can not be considered as an established fact.

SPECIAL ARTICLES

MOMENTUM EFFECTS IN ELECTRIC DISCHARGE

IN the issue of July 17 a partial report was made of experiments on electric discharge around a right angle in a wire. Since then some of the methods have been modified, and additional results have been reached.

In all of the work thus far, an eight-plate static machine has been used. It may be